Feature

How nature copes with climate change

As the world is about to find out whether or not our civilisation is up to the challenge of dealing with climate change, research shows a wide range of responses from other species, which may benefit or suffer from the change, and mitigate it or make it worse. **Michael Gross** reports.

The year 2015, marking a quarter century after the first “assessment report” from the Intergovernmental Panel for Climate Change (IPCC), was meant to become a “year of action” on climate change, in which the world would prepare a change of its course and seal it with a climate deal at the 21st Conference of Parties (COP21) held at Paris, from November 30th to December 11th. Campaigns were launched to persuade investors to pull their money out of fossil fuel interests, and governments were due to make pledges of how much they would reduce the carbon dioxide emissions of their countries (Curr. Biol. (2015) *25*, R307–R310).

It didn’t quite work out that way. There were elections to win, wars to fight, and public services to be cut, such that by September less than a third of the world’s governments had made the pledges that were due by March. Even though Angela Merkel promised decarbonisation by the end of the century and Barack Obama travelled to Alaska to highlight the dangers of climate change, for most of the year the climate crisis continued to have rather low priority on the political agenda. Meanwhile, fossil fuel subsidies continue to be paid at a rate of $550 billion per year (http://bloom.bg/1HejdDa).

Behind the scenes, however, work on what could become a historic achievement or, conceivably, a historic failure, has progressed in the months leading up to the climate conference. Delegations prepared a draft agreement for the Paris summit at two week-long meetings held at Bonn in September and October. Time will tell whether Paris 2015 will mark a turning point or a point of no return.

Nature’s resilience

In the meantime, the effects of climate change have already become sufficiently prominent for researchers to recognise which species will be able to cope with it and which will suffer.

Some species benefit from man-made change because it gives them more of what they fancy. One ecologically important type of sea grass growing near hydrothermal vents in the waters of Papua New Guinea, for instance, depends on water enriched in carbon dioxide, as it normally is in the proximity of the vents. As the oceans have taken up a significant part of the excess carbon dioxide that humanity has released into the atmosphere, this species will now find its fizz even further away from the vents.

Research from Catherine Collier at James Cook University in Cairns, Australia, has shown that several sea grass species have responded to ocean acidification with enhanced growth (Mar. Biol. (2015) *162*, 1005–1017). This, the authors conclude, is beneficial for other species as well and may make a small contribution to disposing of the excess carbon dioxide, although its effects are likely to be overcompensated by adverse effects on many other species including corals (see below).

Similarly, David Barnes from the British Antarctic Survey has also found that certain organisms thrive on climate change and may boost carbon sequestration. As he recently reported in this journal (Curr. Biol. (2015) *25*, R789–R790), Barnes studied the effect that the loss of sea ice in the Antarctic Ocean has on benthic sea floor communities underneath, using both published and new data on the abundance of six species of West Antarctic bryozoans — a group of invertebrates also known as ‘moss animals’. In the West Antarctic Ocean, sea ice has generally increased in recent years, but there have been some coastal ice shelves, like Larsen A and B, that collapsed and left large areas of the continental shelf without ice cover (Curr. Biol. (2014) *24*, R941–R944).

Bonjour Paris: The French capital hosts the 21st Conference of Parties to the UN Framework on Climate Change, COP21, from 30th November to 11th December. It also observed its first car-free Sunday recently, offering residents and visitors a glimpse at the benefits of a less polluted environment. (Photo: Maxime Lathuilière.)

Winning ways: The common redstart (*Phoenicurus phoenicurus*) is one of the migratory bird species identified in a recent study as a possible beneficiary of climate change. (Photo: Mark Hamblin, rspb-images.com)

The research showed that the productivity of bryozoans in areas that lost sea ice has nearly doubled over the last 20 years. Considering the depth at which these bottom-dwelling organisms grow, there is a good chance that the carbon they assimilate will end up buried in the sediment. While bryozoans only represent a fraction of the total productivity of the benthic community, they are fairly typical. Thus, Barnes extrapolated the effect to the whole benthos and estimated that the loss of sea ice in the West Antarctic Ocean could cause the sequestration of two million tonnes of carbon per year.

"We've found that a significant area of the planet — more than three million square kilometres — is a considerable carbon sink and, more importantly, a negative feedback on climate change," Barnes said. In a lucky coincidence, the area where this phenomenon occurs includes the first high seas marine protected area, located around the South Orkney Islands.

If the extrapolation is confirmed, and if similar effects are also found to be operating in the Arctic Ocean, which has seen much larger losses of sea ice, the carbon drawdown by benthic organisms might emerge as the biggest natural brake on climate change.

Some win, some lose

Responses to climate change can be varied and complex even within groups of species sharing similar habitats and lifestyles, however. Observations of migratory birds, for instance, offer a range of different climate impacts from beneficial to deleterious. A recent analysis of data collected by 50,000 volunteers in 18 European countries covers 51 bird species and shows a complex picture of benefits and losses from climate change (Glob. Change Biol. (2015) http://dx.doi.org/10.1111/gcb.13097).

"We found benefits from conditions observed under climate change for both resident birds, short-distance migrants and long-distance migrants, but at very different times of the year that complement their breeding season. So if we are to predict what the future bird community may look like in Europe, we need to understand how the conditions during breeding will change," lead author Peter Søgaard Jørgensen from the Royal Swedish Academy of Sciences at Stockholm said.

Birds migrating to Europe over longer distances, like the northern wheatear and the common redstart, were found to benefit from the warm summers that Europe has seen in recent decades. However, they may also suffer impacts from climate change effects elsewhere along their migration route, on top of the other factors that have led to a general decline in common bird species, such as habitat loss and hunting (Curr. Biol. (2015), *25*, R483–R485).

European birds that are adapted to the colder climate in northern Europe and stay there through the winter, such as the house sparrow or the carrion crow, have declined and are likely to suffer further with progressive climate change, the research found.

As some species migrate with the shifting climate zones, while others fail to do so, the composition of species communities changes and species are facing novel competitors and enemies. The group of Jonathan Levine at ETH Zurich, Switzerland, has experimentally transplanted alpine plant species to different heights to simulate the effect of climate change and study the ecological consequences of migration and failure to migrate (Nature (2015) *525*, 515–518). The authors conclude from their observations that "accounting for novel competitors may be important to predicting species' responses to climate change." In particular, "species' range dynamics probably depend not only on their ability to track climate but also on the migration of their competitors and on the extent to which novel and current competitors exert differing competitive effects."

Corals feel the heat

Corals are among the species that are most sensitive to climate change (Curr. Biol. (2013) *23*, R635–R637). They suffer from temperature stress, from sea-level rise, and from ocean acidification. As their reefs support roughly a quarter of marine biodiversity, the conceivable disappearance of corals from the oceans would have catastrophic effects for the entire marine system, as well as for large parts of the human population.

Climate change has increased the likelihood and severity of the temperature anomaly known as El Niño, which has caused regional spread of coral bleaching on several occasions in the past. Bleaching happens when unusually high water temperatures persist for longer than a month. The corals respond to this thermal stress by expelling their algal symbionts, on which they depend for nutrition, so they will die unless the algae can return very quickly.

There have been two global coral bleaching events in the past, starting in 1998 and in 2010, each causing massive die-offs from which reefs may only recover in decades, if at all. Evidence of a third such catastrophe was building up by mid-2015, and on October 8th the US National Oceanic and Atmospheric Administration officially confirmed that a third global die-off is underway, triggered again by an unusually strong El Niño (http://1.usa.gov/1LnZXlY). This announcement is based on the NOAA's Coral Watch programme, which uses satellite observation and climate modelling to assess current and future risks to coral reefs. The bleaching is likely to spread and intensify well into 2016, and experts fear that the amount of damage to coral reefs will exceed that observed after the previous two events.

Ove Hoegh-Guldberg, from the Global Change Institute at the University of Queensland, Australia, told the British newspaper *The Guardian* that the new development was in accordance with a prediction he had made in 1999, suggesting that the threat to corals would intensify to an extent that bleaching would happen every year from 2030 onwards and coral reefs might die out by the middle of the century.

However, there is still a chance to save the corals. "If we were to take strong action on the emission issue and we were to take strong action on the non-climate issues, such as overfishing and pollution, reefs would rebound by mid to late century," Hoegh-Guldberg said.

Whether or not the world is prepared to take strong action will become clear at the COP21 meeting at Paris. Failing that, there is the question of whether corals can help themselves and adapt to a warming climate and more frequent occurrence of heat stress. As coral reefs extend across several climate zones, with different species mixtures according to the prevalent temperature conditions, there is a small hope that some may be able to adapt to the chronic problem of climate shifts, as long as the speed of the climate move is commensurate with that of the corals' expansion into new habitats.

But what can corals do about the acute problem of bleaching events, which will be recurring more and more frequently? A recent study suggests that different strains of corals within a species may respond differently to acute thermal stress, raising the hopes that even an apocalyptic die-off of corals will leave some especially resilient survivors. Iliana Baums and colleagues from Penn State University, USA, investigated the temperature response of corals in the Caribbean, near Puerto Morelos, Mexico.

Endangered habitat: Coral reefs around the world are now facing a third global bleaching event. In the absence of drastic measures to curb climate change, they may die out by the middle of the century, one expert has warned. This would affect many marine species that depend on the habitat and protection the reefs provide. (Photo: Ritiks/Wikimedia Commons.)

The researchers used DNA markers to distinguish between six different strains of the Elkhorn coral, *Acropora palmata*, all sharing the same strain of algae as their symbionts. When the researchers exposed these pairings to experimental temperature stress, they found that some of the coral strains were better able to protect their symbionts than the others. Transcriptome analysis showed that the more protective corals had a massive response to the experimental temperature change involving 184 genes changing their expression level, while the less protective strains only adjusted the transcription of 14 genes.

"Our study provides a glimmer of hope that corals can respond to and survive climate change, as long as it's not too fast," said Iliana Baums. "The variation in response to extreme temperature that we observed is the raw material for evolutionary change and indicates that these corals may be more adaptable than previously thought."

The main challenge

After 25 years of officially documented man-made climate change, observations provide a preliminary impression of how nature responds to the challenge. A complex picture emerges, in which some species migrate, some adapt, and others die out. Ecosystems and food webs will change. Unexpected and unpredictable complexities are bound to arise along with the predicted changes. Some of the effects will slow down climate change by absorbing more carbon, but it is to be feared that the beneficial effects will be outweighed by large positive feedback loops, such as the thawing of permafrost resulting in additional release of greenhouse gases.

Thus, the modest contributions of natural adaptation and mitigation should not distract us from the main challenge that our civilisation faces at COP21 Paris: how to stop our excessive emissions of carbon dioxide and curb climate change before it is too late.

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